Robots, artificial intelligence, and genetic engineering: The realm of science fiction until very recently.

Who can forget Arthur Clarke and Stanley Kubrick's sci-fi masterpiece, "2001: A Space Odyssey," in which a spaceship headed for Jupiter is taken over by its intelligent computer, the HAL9000. Recall when the spaceship captain tells HAL to open the pod bay doors, and HAL responds, "I'm sorry Dave. I'm afraid I can't do that." HAL has apparently turned rogue, acting independently of its programmed role for its own nefarious purposes, commandeering the spaceship and killing most of the humans on board.

That 1968 movie was my first encounter with artificial intelligence as it was for millions of sci-fi fans and was so disturbing to me that I had nightmares. However, I reasoned, it was only science fiction.

The entertainment industry soon moved on to even more terrifying scenarios - including the idea that the genetic makeup of humans could be altered.

In 1982, "Blade Runner" was released featuring "replicants," genetically engineered super-humans, stronger, smarter, and more agile than their human makers. Then there's "The Fly," the 1958 science-fiction horror film and its 1986 re-make, depicting horribly-gone-wrong genetic modification in a human.

But again, these films and others like them were science fiction, frightening but not real, a distant possibility.

Now, 50 some odd years later, we find ourselves in the midst of robots, artificial intelligence and genetic engineering in the real world. After seeming like a distant possibility for so many years, how have these technologies suddenly landed in the present?

In their book, “The Second Machine Age,” Erik Brynjolfsson and Andrew McAfee propose two distinct developments that most profoundly bent the curve of human history and social development. The First Machine Age began with the development of the steam engine by James Watt in the mid 1700’s. His machine captured massive amounts of mechanical power, to make the steam engine one of the great inventions of all time, ushering in the Industrial Revolution. (4, p 5)

Mankind has now entered a new era, as important and life-changing as the Industrial Revolution, what Brynjolfsson and McAfee call the Second Machine Age. This time, it isn’t muscle power that’s being developed. It’s MENTAL power, the ability to use our brains to understand and shape our environments - just as the steam engine and its descendants did for muscle power. (4, p 8) And this new machine age was ushered in by the development of the computer.

While computers became generally available in the 1980s, it wasn’t until the web grew widely available in the 1990s that progress in these fields began to ramp up toward today’s incredible pace. Prior to that people worked more or less alone or in groups within companies or universities or to some extent across early incarnations of the internet. As the Web matured, people from around the world began to collaborate on open source projects that interested them, and these became the foundations for the explosion of software innovation that we see today. (30)

So robots, artificial intelligence, and genetic engineering controlled by man, are quite recent developments. We have moved from the analog world to the digital one. And because of this, development in these applications has grown with exponential rapidity.

Of the three technologies under consideration, Genetic Engineering retains the most profound connection with the analog world. Because unlike the other two, it is first and foremost a biological process.

Genetic engineering should not be confused with cloning, a procedure that simply copies the genetic makeup of an organism. In clones, the DNA is exactly the same in all copies.

Since farming began, man has attempted to improve livestock by selectively breeding animals with superior characteristics in hopes of improving desired qualities in offspring. Plants, too, were hand-pollinated to improve taste or durability of future crops. The disadvantage: Results took years, even decades to observe.

The genetic engineering of today is an intentional manipulation of a subject's genes. Basically, a gene of interest, from sources like bacteria, viruses, plants or animals is inserted into the target organism. As a result, the organism with the inserted "gene of interest" is now able to carry out the new trait or characteristic. And that new trait is passed on to future generations. (8)

Although several methods of inserting new DNA into a subject exist, since 2012, the cutting edge genome-editing technique called CRISPR-Cas9, or simply CRISPR, has become the darling of gene editing. (25)

CRISPR, is an acronym for 'clustered regularly interspaced short palindromic repeats.' It's a molecule, first discovered in the bacteria Streptococcus pyogenes, (better known as the bacteria that causes strep throat,) that "finds a string of DNA code, locks on and makes a precision cut.

And because scientists can tune it to target any genetic sequence, they can use it to turn genes off or replace them with new versions." (25)

Scientists hope CRISPR can one day be used to correct genes which lead to diseases in humans, or introduce genes which protect us from disease. For instance, Huntington's disease is caused by an inherited defective gene that causes progressive degeneration of nerves located inside the brain. Symptoms commonly appear when a victim is in his or her 30s or 40s and include jerky, uncontrolled movements, slurred speech, balance problems, mood swings, and cognitive decline. The tragedy of Huntington's disease is that by the time symptoms occur, those with the disease have already passed the defective gene on to any children they have. The Huntington Disease gene mutation is dominant, meaning that a child only needs to inherit one copy of the mutated gene to experience its effects. (16)

Recent work from multiple research groups has shown that CRISPR can be used to edit the Huntington gene in the brain of a living mouse. "Even more exciting, one lab's newest findings show improved behavior in mice with Huntington's disease after delivering CRISPR to the brain." (7)

Other diseases that could be completely eliminated with this gene-editing technology include HIV, sickle-cell anemia, muscular dystrophy, Tay Sachs, cystic fibrosis, and hemophilia. (25) While transplants from other species, say pigs, to humans, is still in the experimental stage, with CRISPR, genes might be edited to make foreign organs acceptable to the immune system of humans.

In agriculture, a new potato, resistant to the pathogen that caused the Irish potato famine, has been genetically engineered by an Idaho potato company by inserting genes from an Argentine variety of potato with natural immunity to the blight. Because the inserted gene is from the same species, the potato has been approved by both the US and Canadian regulatory agencies for planting and trade between the two countries. (26)

The USDA reports that genetically modified seeds are used to plant more than 90% of sugar beets, canola, corn, soybeans and cotton grown in the US. Genetically modified foods are everywhere. (11)

According to the Pew Research Center, nearly 40% of Americans think GMOs are bad for their health. While this is not supported by scientific research, a good percentage of GMO foods are not welcome in European countries. Two decades of research have shown that skepticism of genetic modification is largely fueled, not by ignorance or technophobia, but by a lack of trust in large corporations. Monsanto and DuPont are two giants in the GMO world, and with a history of products including Agent Orange, DDT, PCBs and Polystyrene, it's perhaps understandable that Americans are wary. (11)

There are numerous negatives to genetic engineering. Manipulated foods may cause allergies for some. Conferring immunity to diseases in plants and animals may transfer that immunity to pathogens as well, making super bugs that are resistant to known treatments. While relieving one problem, the treatment may cause the onset of another. Increasing the yield of a plant, could decrease the nutritional value. Genetically engineered species can have a negative impact on domestic species. Since modified species tend to be stronger, unmodified species could soon disappear resulting in decreased diversity. (22)

While the Agriculture Department has indicated that it doesn't intend to regulate CRISPR-edited crops because they don't contain another species' genetic material, GMOs as we have traditionally known them involve inserting target DNA from a different species and are therefore more suspect. (5)

Intentional gene manipulation is a recent science. CRISPR and other genetic engineering processes are not yet ready for general use but the promises of improving mankind's lot are encouraging.

Back in the 1960's, in my biology, chemistry and genetics classes, CRISPR wasn't even a blip on the horizon. It seems to have caught the popular imagination relatively off guard. Not so with robots, which have been a common fixture in the science fiction genre for at least a hundred years.

In 1977, the world fell in love with the bumbling R2D2 and posturing c3pO in Star Wars, which was my first real exposure to robots. I wasn't aware that robots weren't confined to the movies at that time. They were already being used in auto manufacturing factories, the first one being installed by General Motors in its New Jersey plant in 1962.

Robots were developed to perform tasks that are repetitive, distasteful, boring or risky to humans; in other words, to do work that humans don't want to do. Today, there are as many different types of robots as there are tasks for them to perform.

Industrial robots, defined as automatically controlled, reprogrammable machines, are engaged in tasks that range from welding cars to processing poultry. They often work alongside humans. Interestingly, "more than half of America's industrial robot population is concentrated in just 10 states in the Midwest and South." Detroit, the hub of auto manufacturing, is the top robot user with more than 15,000 robots. Ohio and Indiana come in second and third in industrial robot usage. In contrast, the entire western part the country accounts for just 13% of the industrial robot population in the US. (31)

McAfee and Brynjolfsson present a good example of what robots can and cannot do in industry: "On a production line that fills up jelly jars, robotic machines squirt a precise amount of jelly into each jar, screw on the top, and stick on the label, but a person places the empty jars on the conveyor belt to start the process. Why hasn't this step been automated? Because in this case the jars are delivered to the line twelve at a time in cardboard boxes that don't hold them firmly in place. This imprecision presents no problem to a person (who simply sees the jars in the box, grabs them, and puts them on the conveyor belt) but traditional industrial automation has great difficulty with jelly jars that don't show up in exactly the same place every time." (4, p30)

In other words, traditional robots, without the help of artificial intelligence, cannot learn. They simply do what they're programmed to do.

Consider the following positive aspects of industrial robots (at least from a company's point of view): A $40,000 robot is a one-time expense for a company in contrast to a $40,000 per year employee. That robot can work 24 hours a day, 7 days a week. It doesn't get a sore back or aching feet, doesn't need coffee breaks, sick leave, health insurance, or vacation time. It can do more than one task at the same time, provided it has an "arm" programmed for each task. Companies needn't worry about hazardous fumes or radiation, extremely hot or cold working environments, risks from repetitive motions or heavy lifting. And robots don't make mistakes in their programmed roles. "They provide a consistent and regular product which improves both quality and consistency in manufacturing." (3)

There is a reason for workers in industry to dislike robots. Increasing levels of automation means that there could potentially be fewer and fewer jobs for people to do. Robots do not currently eliminate the need for human laborers. They do, however, decrease the number of human workers needed in a factory. The concern is that one day robots may do all of the low-skill labor, leaving a large percentage of people unemployed. (3)

In the medical field, Dr. Scott Boyd, a urogynecological surgeon in Fort Wayne, performs robotic surgery using the da Vinci system. He describes the robot as looking like an oversized periscope that grew tentacles. (28)

A recent national article described an example of the da Vinci system: Nine weeks into her pregnancy, a woman was discovered to have a cancerous tumor on her colon. Although doctors recommended removing the life threatening tumor by cutting it out, this necessitated lifting the uterus to get to the tumor which would put pressure on the fetus, most likely terminating the pregnancy. One doctor, however, recommended using the da Vinci robot to remove the tumor, and the woman underwent surgery using this system. Guided by her surgeon, the robot maneuvered in a way that's literally impossible for the human hand - bending sharply at the wrist to safely bypass the baby in the womb. The robot successfully cut out the tumor along with 18 inches of the woman's colon with no harm to the fetus. Seven weeks later, during her second trimester, she started a course of chemotherapy. She now has a healthy 12 month-old-daughter. (23) Both Lutheran and Parkview Hospitals in Fort Wayne now use da Vinci robots. (28)

Elsewhere in medicine, robots are used in radiation therapy, dispensing of medications, and performing tests on patients at remote sites.

In other fields, robots are now an integral part of investigative work whether on the battlefield or within law-enforcement agencies. For instance, if a bomb is suspected at a crime scene or on the battlefield, a robot can approach the suspected object, clamoring over ruble and climbing up stairs, all the time transmitting footage as the robot's camera looks under vehicles and scans the area. If a potential bomb is suspected inside a vehicle, the robot can tow the vehicle to a more remote location so that bomb experts can analyze it without risk to civilians. (14)

Big Dog is a robot designed to carry heavy loads over rough terrain on the battlefield, and the robot FINDER uses low power radar to detect small movements from the breathing and heartbeat of a buried victim, even through several feet of rubble and debris. (2)

Amazon, Zappos, Staples, The Gap, Wal Mart, and many, many other on-line businesses rely heavily on robots. A self-propelled robot navigates a warehouse, finds the wanted product and transports it back to a human operator who processes the order. Robots continually rearrange the warehouse to place popular products around the facilities perimeter, reducing the time spent to route these products to employees. (14)

Drones, specialized flying robots, can be used to monitor activity in enemy territory, including tracking terrorists, and ominously, to carry weaponry to attack from the sky. More benignly, they are also used by farmers to monitor crops in the field, or by scientists to track, say, polar bears, in the Arctic. Recently, there has been talk of drones delivering Amazon orders to your home or business.

There are, as mentioned, as many different types of robots as there are tasks for them to perform. And each day our machines become capable of performing higher and higher level work - even while certain tasks remain out of their reach. As cognitive psychologist Steven Pinker rather famously stated, "It will be the stock analysts and petrochemical engineers and parole board members who are in danger of being replaced by machines. The gardeners, receptionists and cooks are secure in their jobs for decades to come." (4, p 29) Consider this: iRobot's Roomba, the little self-driving vacuum cleaners seen on TV infomercials won't replace maids anytime soon. Not one of the Roomba models can straighten the magazines on a coffee table or notice spills on the kitchen counter.

There's still a call for human judgement, especially when a job includes unpredictability.

Robots and genetic engineering have become part of our everyday lives. But, what about artificial intelligence? Could HAL9000 become a reality?

Merriam-Webster defines AI as "the theory and development of computer systems able to perform tasks that normally require human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages." (10)

AI can be categorized into three groups, often used interchangeably: artificial intelligence (AI), Machine Learning (ML), and Deep Learning. (24)

All AI to date is Narrow AI (or weak AI) which refers to applications that are skilled at one specific task. Siri is a good example of narrow AI. Siri operates within a limited pre-defined range; there is no genuine intelligence, no self-awareness, no life despite being a sophisticated example of narrow AI. (24)

"In 1997, IBM's Deep Blue computer defeated the reigning world chess champion, Garry Kasparov. Deep Blue, is another example of narrow AI, a program skilled at one specific task. Deep Blue might be unbeatable in chess, but the algorithm could not beat anyone at the game of checkers, nor could Deep Blue tie a shoelace.

In 2011, another IBM computer, Watson, bested humans in the quiz show "Jeopardy!" and won the first place prize of $1 million." (17) Watson is an example of machine learning, a subset of narrow Artificial Intelligence. Watson, in addition to winning at Jeopardy, is applying its skills to solving business problems in the real world. H&R Block, one of America's largest tax preparation providers, is now using Watson, IBM's AI platform. (12)

"Last year, Alpha Go (a predecessor to AlphaGo Zero) rose to international prominence by unexpectedly beating Lee Sedol, a top player in the ancient and sublime Chinese game of Go. Alpha Go was trained on 160,000 games from a database of previously played Go games.

“AlphaGo Zero dispensed with any accumulated human wisdom and decisively annihilated its parent, Alpha Go, 100 to 0.” (17)

But as AlphaGo Zero’s author points out, “Its achievements are also constrained to the highly ordered world of AlphaGo, which is a far cry from the messy and uncertain problems AI will eventually be asked to solve in real life.” Still, researchers at DeepMind are already working on applying similar techniques to those at the heart of AlphaGo Zero to practical applications. In a blog post, DeepMind said the approach could hold promise in other structured problems like protein folding, reducing energy consumption, or material design. (13)

Deep learning is a subset of machine learning that specializes in unsupervised learning from unstructured data. Some applications include visual pattern recognition, language translation, self-driving cars and earthquake prediction. (30)

In 2004, a completely autonomous vehicle race was held in the Mojave Desert. It was a complete disaster. Then, on to 2012, just eight years after the desert debacle, McAfee and Brynjolfsson took a ride in a Google autonomous car, the Chauffeur, on California’s Highway 101. “The car performed flawlessly. It drove exactly the way we’re all taught to in driver’s ed. The car recognized all the surrounding vehicles, not just the nearest ones, and it remained aware of them no matter where they moved. It was a car without blind spots. But the software doing the driving was aware that cars and trucks driven by humans do have blind spots. When traffic ahead came to a complete and unexpected stop, the autonomous car braked smoothly in response, coming to a stop a safe distance behind the car in front, and started moving again once the rest of the traffic did.” (4, p 14,15) The car company Waymo has chosen Michigan as the sixth state where its self-driving car project will test autonomous vehicles. The company chose Michigan to see how vehicles will respond in snow, sleet, and ice. (1)

In other newly announced uses for AI, Japanese researchers demonstrated an artificial intelligence capable of identifying and analyzing polyps found during a colonoscopy. The endoscopic system uses a magnified view of a colorectal polyp to study its features and compare it with 30,000 endocytoscopic images used for machine learning. Researchers said they were able to predict the pathology of the polyp in less than a second, with 86% accuracy, based on a study assessing more than 300 polyps. "The most remarkable breakthrough with this system is that artificial intelligence enables real-time optical biopsy of colorectal polyps during colonoscopy, regardless of the endoscopists' skill," said Dr. Yuichi Mori, a researcher from Showa University in Yokohama, Japan, and the study's leader. (21)

As reported in a recent article in the Wall Street Journal, AI's value to the medical world is a key reason why supporters such as Facebook CEO Mark Zuckerberg are excited about the future of artificial intelligence. During a Facebook Live chat in July, Zuckerberg discussed how AI can create safer cars and diagnose diseases earlier. "I'm just much more optimistic in general on this," he said. Other proponents of AI include Bill Gates who says: ... AI is "on the verge of making our lives more productive and creative." (17) Michael Dell is also a proponent of AI, saying in a recent article: "In the not too distant future, if you're making decisions in your organization without machine learning, you're probably doing it wrong." (35)
Critics of AI, most notably entrepreneur and Tesla CEO Elon Musk, said governments should regulate how artificial intelligence is built and used to prevent potential global disasters. Others who join him include philosopher Nick Bostrom, and physicist Stephen Hawking. (17)
Opponents of AI cite the fact that AI brings many benefits but only for those who are wealthy or gainfully employed. AI will further accelerate the inequality between the haves and the have-

nots. They worry about warfare. “At some point, AI will have the capability to kill without a human in the loop to override its lethality.” (17)

In the Wall Street Journal article, “We’ll Need Bigger Brains,” the authors suggest that we must create technologies that enhance the human brain to keep ahead of the ever expanding world of AI. Many scenarios are being proposed for how humans can enhance their brain-power. Education is the traditional answer, but “training (and retraining) people takes time and not everybody can, or wants to, switch from driving trucks, serving fast food or scanning items at the supermarket, to, say, developing code, designing computer chips, walking dogs or caring for elders (to list a few jobs that won’t be made redundant anytime soon.)” (17)

“Technological progress is going to leave behind some people, perhaps even a lot of people, as it races ahead. There’s never been a better time to be a worker with special skills or the right education…. However, there’s never been a worse time to be a worker with only ‘ordinary’ skills and abilities to offer, because computers, robots and other digital technologies are acquiring these skills and abilities at an extraordinary rate.” (4, p11)

“Think about AI being let loose to tinker with robotics or genetic engineering. Imagine giving something like AlphaGo Zero control of an automated factory, or genetics laboratory, where it could iterate and create new robots or genetic material. Think about our new world with these new technologies of robots, genetic engineering and most especially, artificial intelligence. No longer science fiction. Rather, a very real scientific reality.